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Review

Research on non-invasive monitoring of biomechanical and viscoelastic properties of myotendinous complex in patients with herniated disk with radiculopathy (pre- and post-surgery) in the in order to optimize the neurorehabilitation approach – a systematic literature review

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Abstract: Low back pain is considered to have "epidemic proportions in Western societies", so that it is obvious that discovertebral pathology, especially severe (as is the case with neurosurgical indications), which is our subject research, succita a major and constantly growing interest due to, including to the numerical pressure, which places it among public health problems. This is also reflected by the fact that, for example, in the United States, in recent decades, healthcare costs allocated to prescription drugs to combat lumbosacralgia have risen at a higher rate than in any other category of health services [1]. In our study, we consider that evaluating the viscoelastic properties of muscles provides valuable information about muscle health, function, and progress in recovery. This innovative approach involves assessing the muscle's ability to resist deformation and return to its original shape, which reflects its characteristics of elasticity and viscosity. [2] We previously conducted a systematic review of the related literature using the method of filtering and selecting profile documentary material, a widely accepted and internationally recognized approach: Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Thus, we searched using contextually relevant combinations and syntaxes of search keywords in the following international databases: Elsevier, PubMed, PMC, PEDro, and articles published in English in ISI-indexed journals in Web of Knowledge/Science, from January 1, 2021, to December 31, 2023.

Keywords: acute low back pain, myotonometry, pre-surgery, post-surgery, disc hernia, viscoelastic, biomechanical assessment, tensiomyographic properties, skeletal muscle;

1. Introduction

Low lower back pain - localized between the edge costal and gluteal folds - is a very common, and degenerative intervertebral (including lumbosacral herniated lumbosacral disc, is a common cause, in fact 'lumbar discogenic low back pain and is the most common type of chronic low back pain[3], affects men and women equaly[4] and can be accompanied by lumbosciatica (L5,S1) and/or lumbocruralgia (L2, L3, L4). The clinical picture of low back or lumbosacral pain - most commonly most often generated by HDL - may or may not be accompanied scoliosis, lower limb irradiation and/or sensory and/or motor changes. These may appear clinically (and electroneuromiographically) - corresponding to the rootaffected spinal nerve root(s)[5]. Root pain usually results from various injuries mechanical: herniated disks, spinal canal stenosis, degeneration of the facet joints, synovial cysts and congenital anomalies. These mechanisms classify patients into patients presenting with

sciatica with compression, nerve roots (true sciatica), patients without nerve root compression (referred pain)[6]. About with referred pain, as a result of endo- as well as exogenous phenomena - not all completely known - that occur during embryogenesis (intrinsic vectors of the forces, including various constraints, such as the intrinsic vectors morphological/ neuro-ectoderm - neuroepithelial development) results in a spatial discrepancy between myelomere position and sites of occurrence - through the intervertebral foramina – of corresponding spinal nerve roots from which they originate. This discrepancy increases progressively in the cranio-caudal direction and is the anatomical basis of the cauda equina: for the roots distal sacral and coccygeal, the discrepancy is up to 10 segments vertebral bone[7].

Historically, lower extremity pain with radicular distribution has been described by ancient Greek and Roman physicians, but they generally attributed them to diseases of the hip joint. Hippocrates (460-370 BC) was supposedly the first to use the term 'sciatica' (derived from the Greek 'ischios' - hip). A also noted symptoms that were weather-dependent, i.e. more frequent in summer and fall and also reported manipulation joints and use of traction[8]. In the 19th century, European physicians observed herniated intervertebral discs during autopsies, among them François Valleix and Hubert von Luschka. The first (recorded) successful removal of an intervertebral disk was performed at the beginning of the 20th century by Fedor Krause and Hermann Oppenheim, in 1901, by laminectomy on the of a lesion considered to be an enchondroma. In 1934, William J. Mixter and Joseph S. Barr published a paper on intervertebral disk rupture with spinal canal involvement - paper considered to have opened the era of surgery for spinal of the intervertebral disc.[6]. The onset of low back pain is often associated with bipedal walking. Theories propose that this transformation in locomotor mechanics to be the evolutionary event that hasmade the lumbar spine susceptible to degenerative disease[9].

In our study, as part of the recovery process from muscle injuries or surgery interventions, an important role is played by monitoring progress in guiding the treatment plan. Myoton can be used to assess the initial condition of muscles and soft tissues before surgical treatment (preoperative and postoperative, respectively at the initiation postoperative treatment), to determine the prognosis functional recovery prognosis, to set recovery goals recovery goals, to assess the patient's status over time and to guide treatment content. Miotonometri may be useful in assessing the patient's ability to return to pre-injury or pre disc pathology with neurosurgical indication. Accurate measurements can help determine when optimal time to resume normal activities and sports and can provide guidance in setting realistic goals recovery goals[10],[11]. Without repeating what is well known, namely the huge frequency of lumbosacralgia, of which discogenic lumbosacralgia is the most common type such chronic suffering affects 40% of the general population. This percentage of patients recognizes an episode of lumbosacralgia in the last 6 months, and its overall prevalence throughout ontologic cycle, of such suffering is between 70 and 84% of the population[1].

Method: In order to identify the current state of the research and the level of knowledge regarding the chosen topic, we conducted a systematic literature review in this regard. We queried the following prestigious international medical databases to check whether potentially keyword-eligible articles are indexed in this international reference medical database.

We used as a method for filtering and selecting documentary material, which is widely used and internationally accepted: Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 9 articles remained to be screened full text for eligibility, of which we selected 3[12-14]. We have included in the evidence base for this in addition to those obtained through the selection of PRISMA selection and a number of papers freely identified in other bibliographic sources[15-21].

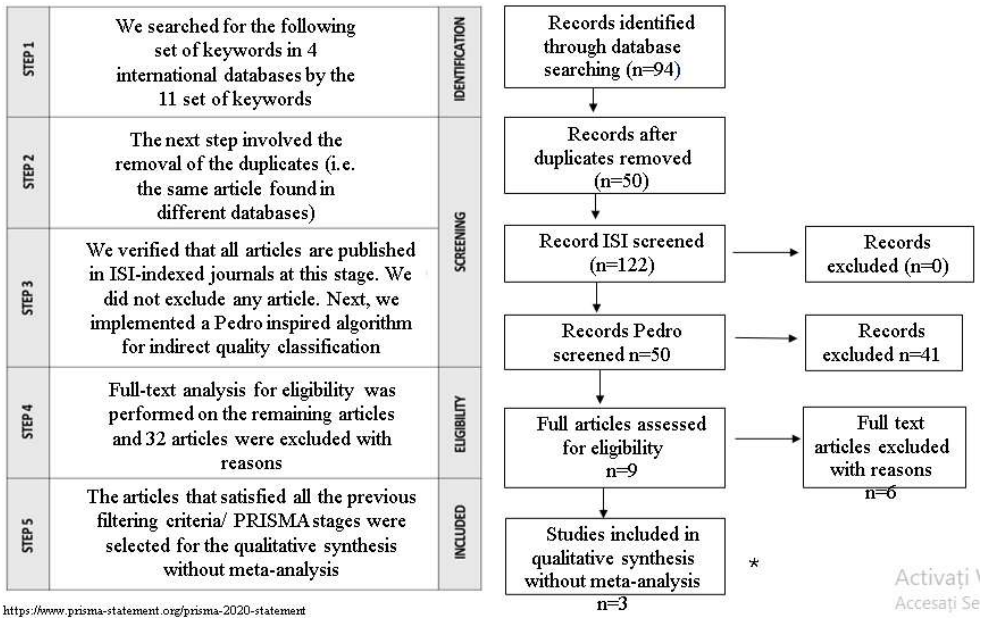
The extensive searches that we carried out resulted in a extremely limited number of articles, which shows that this research topic current research is not sufficiently in-depth and as such justifies its choice because there is a promising area/niche in this direction for possible contributions personal contributions.

The statistical analysis will be performed using SPSS v. 24 (Package Statistical Package for Social Sciences, version 24) and Microsoft Excel 2007 and will include demographic data, descriptive statistics, tests comparison data/tests, parametric data/parametric difference tests or, depending on (non-)normality of the data, non-parametric, possibly including correlation tests, graphical representations by diagrams and/or histograms. Values will be considered statistically significant if: $p < 0,05$. The 95% confidence level with confidence intervals confidence intervals related to specific calculations. Specific statistical tests will also be used, such as the t-test to analyze the effects of physiotherapy treatment on muscle viscoelasticity, and the ANOVA test, which can analyze the variations in muscle viscoelastic properties over time. It reduces the risk of type I (pseudopositive) errors.

Table 1. Keyword/ "syntaxes" selected for our article and the results found in each database.

Keyword/syntaxes	Elsevier	PubMed	PMC	PEDro	Total
"acute low back pain" + "myotonometry" + "pre surgery"	0	0	0	0	0
"acute low back pain" + "myotonometry" + "post surgery"	0	0	0	0	0
"disc hernia" + "myotonometry" + "pre surgery"	0	0	0	0	0
"disc hernia" + "myotonometry" + "post surgery"	0	0	0	0	0
"disc hernia" + "viscoelastic" + "pre surgery"	16	0	2	7	25
"disc hernia" + "viscoelastic" + "post surgery"	17	0	2	1	20
"disc hernia" + "visco-elastic" + "pre surgery"	2	0	0	0	2
"disc hernia" + "visco-elastic" + "post surgery"	2	0	0	0	2
"disc hernia" + "biomechanical assessment" + "pre surgery"	22	0	0	1	23
"disc hernia" + "biomechanical assessment" + "post surgery"	28	0	0	0	28
"acute low back pain" + "tensiomyographic properties" + "skeletal muscle"	0	0	0	0	0
"acute low back pain" + "tensiomyographic properties" + "viscoelastic"	0	0	0	0	0
"acute low back pain" + "tensiomyographic properties" + "visco-elastic"	0	0	0	0	0
"sciatica" + "myotonometry" + "skeletal muscle"	0	0	3	0	3
"sciatica" + "myotonometry" + "viscoelastic"	0	0	0	0	0
Total	87	0	7	9	103

Fig.1 The specific diagram of our PRISMA type of search and selection



Selected articles explore the relationship between low back pain (acute or chronic) and biomechanical characteristics of muscles, such as stiffness and elasticity. Most of the studies mentioned use myotonometry to assess the viscoelastic properties of lumbar or other paraspinal muscles. make comparisons between healthy subjects and those with low back pain to understand biomechanical differences, analyze biomechanical changes following interventions, whether surgery, exercise or other treatments, involve combined assessment methods such as the use of biomechanical methods, imaging (e.g. MRI or ultrasound) and complex statistical analyses. These elements underline a common framework in research focused on biomechanics and pathology of the low back, making a valuable contribution to the understanding and treatment of low back pain.

Study design is prospective longitudinal case-control. Pre-operative and immediate, one-week and two-week follow-up, post-surgery. Study group of approximately 200 patients diagnosed with lumbar disc herniation, with indication for treatment surgical treatment, hospitalized in the Clinical Neurosurgery Departments of SCUBA. Patients will be included only after obtaining Consent from the patient. The study will be carried out in the Neuromuscular Recovery Clinic (RNM) with the support of the Neuromuscular Neurosurgery Clinics of Bagdasar Arseni Emergency Hospital, Bucharest (SCUBA). This study research will be carried out with the approval of the SCUBA Bioethics department.

Discussions:

We have as objectice periodic assessment of changes in status muscle during the recovery period via immediate measurements: perform Myoton in the first 24-48-78 hours postoperatively to assess immediate muscle response and weekly assessments: take measurements with Myoton at the end of each week to monitor long-term progress[22,23]. In addition to rapid and accurate assessment of myoelastic properties of muscles with Myoton we will use other tools of measurement or evaluation:

VAS scale (VisualAnalogueScale), Oswestry Disability Index (Oswestry Disability Index), Roland-Morris Disability Index Questionnaire) - Used to assess disability related to low back pain, contains 24 statements about physical limitations and

activities of daily living, Functional Mobility Scale – Assessment, functional mobility skills such as walking, climbing stairs and other daily activities, Musculoskeletal Disability Assessment Scale (Musculoskeletal Function Assessment (MFA) - A detailed assessment of musculoskeletal function and its impact on daily life, 6-Minute Walk Test (6MWT) post HDL, Southampton Score: assesses surgical wound healing and identifies wound complications[24], ASEPSIS score: Assess surgical wound infection based on clinical signs and treatment required (Surgical Wound Function Assessment Scores)[25], WQuality of Life Scale - WHO QoL BREF), Specific scales such as SF-36 (Short Form Health Survey) or EuroQol (EQ-5D) are commonly used to assess quality of life aspects post-operative[26].

Conclusions:

Correlating the data collected using Myoton and the algic symptoms recorded on the VAS scale can provide valuable insight into the relationship between muscle properties and pain. Through systematic data collection, rigorous statistical analysis, and careful interpretation of the results, it is possible to optimize recovery treatment strategies for patients with herniated discs, contributing to a significant improvement in their quality of life. Measurements made using myotonometry can positively influence the recovery process in physiotherapy, providing valuable and personalized information about the condition of the muscles. ways in which they improve outcomes: Myotonometry helps to measure the viscoelastic properties of muscles (such as stiffness, elasticity and muscle tone) before starting physiotherapy. This information allows to establish an objective starting point for the treatment plan. Based on the results of the measurements, therapists can tailor the exercises to suit the patient's specific needs. For example, muscles with increased stiffness may require muscle relaxation techniques, while weaker muscles may require strengthening exercises. By repeating the measurements during the recovery process, it is possible to track changes in muscle properties over time. This provides clear feedback about the effectiveness of the interventions applied. Myotonometry can detect unexpected strains or changes in muscles, helping to adjust the program to avoid complications or further injury. The results of objective measurements can be correlated with patient-reported improvements (e.g., reduced pain or increased functionality), providing a complete picture of the success of physiotherapy. By integrating myotonometry into recovery, the process becomes more accurate and better targeted to the individual needs of the patient.

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References

1. Braddom RL et al. – Physical Medicine & Rehabililitation (3rd edition). W. B. Saunders Company, Philadelphia, U.S.A., 2007
2. Nguyen AP, Detrembleur C, Fisette P, Selves C, Mahaudens P. MyotonPro Is a Valid Device for Assessing Wrist Biomechanical Stiffness in Healthy Young Adults. Front Sports Act Living. 2022 Feb 21;4:797975. doi: 10.3389/fspor.2022.797975. PMID: 35265831; PMCID: PMC8899712.
3. Peng BG. Pathophysiology, diagnosis, and treatment of discogenic low back pain. World J Orthop. 2013 Apr 18;4(2):42-52. doi: 10.5312/wjo.v4.i2.42. PMID: 23610750; PMCID: PMC3631950
4. Patel RK, Jain M (2012) NGS QC Toolkit: A Toolkit for Quality Control of Next Generation Sequencing Data. PLoS ONE 7(2): e30619. https://doi.org/10.1371/journal.pone.0030619
5. https://doi.org/10.1590/S1413-78522002000400003
6. Poiraudeau S, Foltz V, Drapé J - L, Fermanian J, Lefèvre - Colau MM, Mayoux - Benhamou MA, Revel M – Value of the bell test and the hyperextension test for diagnosis in sciatica associated with disc herniation: comparison with Lasègue's sign and the crossed Lasègue's sign. Rheumatology 40 (4): 460-466, 2001; doi: 10.1093/rheumatology/40.4.460
7. Gelu Onose – (Tratat de "Recuperare, Medicnă Fizică și Balneoclimatologie - notțuni de bază și actualiățti" – Vol. I. Editura Medicală, București, 2007

8. Pearce, J. A brief history of sciatica. Spinal Cord 45, 592–596 (2007). https://doi.org/10.1038/sj.sc.3102080
9. Patel RK (Ch. Ed.), Cailliet R et al. – 2012 – Lumbar Degenerative Disk Disease http://emedicine.medscape.com/article/309767-overview
10. Pruyn EC, Watsford ML, Murphy AJ. Validity and reliability of three methods of stiffness assessment. J Sport Health Sci. (2016) 5(4):476–83. doi: 10.1016/j.jshs.2015.12.001
11. Wiesinger HP, Rieder F, Kosters A, Muller E, Seynnes OR. Are sport-specific profiles of tendon stiffness and cross-sectional area determined by structural or functional integrity? PLoS One. (2016) 11(6):e0158441. doi: 10.1371/journal.pone.0158
12. Mika Brown, Jianyu Li, Christopher Moraes, Maryam Tabrizian, Nicole Y.K, Li-Jessen, Decellularized extracellu-lar matrix: New promising and challenging biomaterials for regenerative medicine, Biomaterials, Volume 289, 2022, 121786, ISSN 0142-9612, https://doi.org/10.1016/j.biomaterials.2022.121786
13. Anuj Kumar, Ankur Sood, Garima Agrawal, Sourbh Thakur, Vijay Kumar Thakur, Masaru Tanaka, Yogend-Kumar Mishra, Graham Christie, Ebrahim Mostafavi, Rabah Boukherroub, Dietmar W. Hutmacher, Sung So-Han, Polysaccharides, proteins, and synthetic polymers based multimodal hydrogels for various biomedical applications: A review, International Journal of Biological Macromolecules, Volume 247, 2023, 125606, ISSN 0141-8130, https://doi.org/10.1016/j.ijbiomac.2023.125606
14. Mallory Perry, Christine B. Sieberg, Erin E. Young, Kyle Baumbauer, Vijender Singh, Cindy Wong, Angel Stark-weather, The Potential Role of Preoperative Pain, Catastrophizing, and Differential Gene Expression on Pain Outcomes after Pediatric Spinal Fusion, Pain Management Nursing, Volume 22, Issue 1, 2021, Pages 44-49, ISSN 1524-9042, https://doi.org/10.1016/j.pmn.2020.05.007
15. Alcaraz-Clariana S, García-Luque L, Garrido-Castro JL, Carmona-Pérez C, Rodrigues-de-Souza DP, Fernádez-de-Las-Peñas C, Alburquerque-Sendín F. Influence of Spinal Movements Associated with Physical Evaluation on Muscle Mechanical Properties of the Lumbar Paraspinal in Subjects with Acute Low Back Pain. Diagnostics (Basel). 2022 Jan 25;12(2):302. doi: 10.3390/diagnostics12020302. PMID: 35204392; PMCID: PMC8870934.
16. Lo WLA, Yu Q, Mao Y, Li W, Hu C, Li L. Lumbar muscles biomechanical characteristics in young people with chronic spinal pain. BMC Musculoskelet Disord. 2019 Nov 23;20(1):559. doi: 10.1186/s12891-019-2935-z. PMID: 31759390; PMCID: PMC6875033.
17. Li Y, Yu J, Zhang J, Zhang Z, Wang X. Quantifying the stiffness of lumbar erector spinae during different posi-tions among participants with chronic low back pain. PLoSOne. 2022 Jun 24;17(6):e0270286. doi: 10.1371/journal.pone.0270286. PMID:35749429; PMCID: PMC9231815.
18. Wu Z, Zhu Y, Xu W, Liang J, Guan Y, Xu X. Analysis of Biomechanical Properties of the Lumbar Extensor Myo-fascia in Elderly Patients with Chronic Low Back Pain and That in Healthy People. Biomed Res Int. 2020 Feb 18;2020:7649157. doi:10.1155/2020/7649157. PMID: 32149135; PMCID: PMC7049445.
19. Wu Z, Wang Y, Ye Z, Guan Y, Ye X, Chen Z, Li C, Chen G, Zhu Y, Du J, Chen G, Liu W, Xu X. Effects of Age and Sex on Properties of Lumbar Erector Spinae in Healthy People: Preliminary Results From a Pilot Study. Front Physiol. 2021 Sep 20;12:718068. doi:10.3389/fphys.2021.718068. PMID: 34616306; PMCID: PMC8488426.
20. Junhyeok Go, PT, PhD, 1, Hojung An, Prof., PhD, Effects of Lumbar Mobilization on the Paravertebral Muscle Activity and Muscle Tone in Patients with Lumbar Spinal Stenosis, Journal of International Academy of Physi-cal Therapy Research - April 2021, Volume 12, no.1, pages 2302-2307 (DOI: 10.20540/JIAPTR.2021.12.1.2302
21. Yasuda T, Jaotawipart S, Kuruma H. Effects of Thoracic Spine Self-mobilization on Patients with Low Back Pain and Lumbar Hypermobility: A Randomized Controlled Trial. Prog Rehabil Med. 2023 Jul 22;8:20230022. doi: 10.2490/prm.20230022. PMID: 37483879; PMCID: PMC10359721.
22. Pruyn EC, Watsford ML, Murphy AJ. Validity and reliability of three methods of stiffness assessment. J Sport Health Sci. (2016) 5(4):476–83. doi: 10.1016/j.jshs.2015.12.001
23. Wiesinger HP, Rieder F, Kosters A, Muller E, Seynnes OR. Are sport-specific profiles of tendon stiffness and cross-sectional area determined by structural or functional integrity? PLoS One. (2016) 11(6):e0158441. doi: 10.1371/journal.pone.0158
24. Tendon elasticity and muscle function. Comp Biochem Physiol A Mol Integr Physiol. 2002 Dec;133(4):1001-11. doi:10.1016/s1095-6433(02)00143-5. PMID: 12485689.
25. https://www.elsevier.com/
26. https://www.ncbi.nlm.nih.gov.